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Canals and Their Economic Relation to Transportation.

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The science of Engineering is pre-eminently one of economics. Most of the problems arising in practice involve the adaptation of the means to the end, in the most judicious manner. The question which invariably presents itself to the engineer is, how to obtain the best result at the least cost of construction and maintenance. This is a complicated problem not to be solved solely by the aid of formulæ or mathematics, although they are important auxiliaries, but largely by experience, precedents and good judgment. It includes also a careful weighing of the relations of cause and effect, action and reaction, revenue and expense, which are functions of many variables; but the physical elements of the problem may be readily reduced to finding the *locus of the line of least resistance*, which will, in general, be that of least cost and greatest revenue. Such is in substance the task submitted to the projector of a new line of communication.

He is to seek out the location which will cost the least, be most direct, produce the minimum of mechanical resistances, develop the maximum amount of traffic at paying rates and cost the least to maintain and operate. Here too the question of time, or velocity of transit, enters as an important factor, not to be overlooked.

The more closely the solution may be made to comply with these conditions the better will be the result; hence it becomes necessary to consider the character of the physical resistances to be surmounted in selecting such a line, in connection with the kind of traffic, motive power, speed and cost of movement.

The principal resistance to be overcome is that produced by the force of gravity acting upon a body moving over an inclined plane. If the direction of the movement be downward, the effect of the force is to produce an acceleration—thus diminishing the amount of any auxiliary power which may be required to propel the load; if upward, a retardation ensues and a consequent increase of power will be required. It has therefore become a maxim in transportation that the grades should be with the heavier traffic.

Since flowing water naturally seeks the line of least resistance and will not run up hill, it is but rational to find the rivers utilized, so far as their variable stages will permit, for purposes of traffic as well as for water supply and power;—but the channel being sinuous, and not often lying in the direction of the desired movement, artificial canals were soon cut for the purpose of still further adapting this natural roadway to the wants of mankind.

Moreover, the frictional resistances of a solid passing over or through a fluid and the great superiority of the latter as to continuity and smoothness, over a roadbed of any solid material, are advantages which no mechanical constructions can hope to rival, and give to the waterway an inherent element of cheapness which cannot be excelled. If therefore the terminals of a line can be connected by water at a cost even greater than that required for rail, it would seem to be the logical and proper channel of transportation. Here, however, arises one of the difficulties, for the applicability of the water route is restricted to relatively narrow limits by the topography as well as the metrology of the country, whilst the railway possesses almost unlimited range in both vertical and horizontal directions, and there are no obstacles which it may not either surmount or pierce.

Where water is abundant, however, the vertical range of a canal may be greatly extended by the use of locks, thus rendering it practicable even in hilly sections, and there are very extensive areas in the United States where it would only be necessary to open what might be regarded as an irrigating ditch, without locks, to provide the necessary communications as feeders to trunk lines for a large proportion of the population in the great basin of the Mississippi and its tributaries.

The great flexibility of the railway system, enabling it to ramify into all parts of the terrane, has resulted in the enormous development of 158,000 miles in about half a century, in the United States alone, and has caused the superior advantages of the water way to be either overlooked or ignored. A reason for this may be found doubtless in the fact that the general government claims jurisdiction over the improvement of all navigable waters not lying wholly within states, and hence it is difficult if not impossible, for corporate powers to execute any works which would look to their amelioration or utilization without first securing the consent of Congress, which, in many cases, involves a serious loss of time, with great uncertainty as to the result.

So long as the policy of "here a little and there a little" exists, nothing can be expected for a rational and systematic development of these natural channels of commerce, and the attention of economists interested in the cheapening of transportation, and in the enriching of the country by encouraging mining, manufactures, agriculture, and all those industries which are dependent upon the movement of materials or products, must be restricted to the development of such artificial water ways as may be practicable, and give fair promise of returns.

Here again the field is greatly restricted by a policy of railroad companies, which has resulted in many cases in the roads purchasing the control of existing canals in competition with their lines, under the impression that such canals were injuring their business. It was found to be an indisputable fact that the cost of movement by canal was less than that by rail, and hence the determination to exterminate or control the former. The result is that the producer must pay the increased rail tariff to the railroad company, while the volume of the movement is largely decreased, for many articles which before had a market value at the lower rate are now rendered worthless.

Nevertheless the competition with the few surviving canals and with other railroads has compelled the managers of these lines to seek every possible method of reducing expenses and of lessening the tariffs so as to approximate to those by water carriage, but even yet they are still in excess of the rates by these artificial channels.

The most recent movement in the direction of economy over land is the large increase of carrying capacity of the rolling stock whereby the ratio of live to dead load is about doubled, being now nearly or occasionally fully two to one. If there be no back loading it is equivalent to one to one for the round trip, other things being equal. But this increase of rolling load involves additional expenditures for road-bed and maintenance, thus adding to the capitalization. Still the great reductions effected, at the present time, by the most thorough system and rigid economy, are not yet able to bring the cost of movement by rail within reach of that by canal. If the comparison be made with deep draught vessels on rivers, lakes, or the ocean, the results are far more unfavorable for the railroads.

Thus if the cost of transportation on the Erie canal be taken as a basis, there will result the following values :

Cost by canal per ton per mile.....less than	3.0	mills.
Cost by lake, 14 to 16 feet draught..........	1.2	“
Cost by ocean, 25 feet draught..............	0.5	“

If the canal boat depth be taken at five feet, that of the lake propellor at fifteen, and that of the ocean "tramp" at twenty-five, their ratios will be as one to three, to five. The reciprocals of these numbers are one, one-third and one-fifth, or 1, 0.33 and 0.20 ; while the relative rates reduced to the unit as a standard would be one, something more than 0.40 and a little over 0.17, varying with the canal rate per ton per mile.

By comparing these figures it will be seen that at these rates, they are so nearly coincident as practically to be stated in the form of a law, viz : *The cost* *of movement on water is inversely proportional to the draught of the vessel.* It is true that we are here comparing artificial and natural waterways, but as this canal is the enlarged Erie, and free of tolls, the cost will not differ very greatly from an improved river navigation of equal draught.

These results demonstrate the great economy of increased draught, and furnish a clue to the reason for the abandonment or failure of many of the early canals as constructed in the first three decades of this century with their insufficient depths and limited capacity.

To obtain increased draught, it may be urged that the prism of excavation for a given length of canal must increase as the square of the depth, whilst the cost of movement only varies inversely as the first power. But the capital invested in construction is only one factor in the cost of operation, and the length of the boat may be increased without adding materially to the resistance which it generates in passing through the water. If the beam be also widened proportionately the capacity of the boat may be made to increase as the cube of the depth, while the cost of construction will vary as a fraction of its second power.

With this view of the subject it will certainly merit the attentive consideration of traffic managers, as well as consumers and producers who are so vitally affected by the tariffs on freight.

Again, if it be true, and there would seem to be little room for doubt, that on a well appointed and well managed canal the *cost* of traffic is less than on a standard railroad, why should not the managers of such roads, who may at the same time control a parallel line of canals, transport a large portion of the lower grade freights via the water way with the same profit to the shareholders and a greater benefit to themselves and the producers due to the lesser tariff? Such a policy has invariably resulted in augmenting the business and increasing the profits ; and it is difficult to understand why it should not be more generally realized and adopted.

In an argument before the Committee on Commerce, several years since, Mr. Albert Fink, then the railroad Commissioner of the Trunk Lines, stated :

> "The competitive railroad tariffs for the interstate commerce are not, as is so generally supposed, under the absolute control of railroad managers, but the carriers by the water routes really establish these tariffs, and the railroad managers have nothing to do but to conform to them. The water routes not only control the tariffs of these immediate railroad competitors, at points where they can render like service to the same people, but their influence reaches directly and indirectly to the remotest parts of the country. * * * It will thus appear that the railroad companies fully recognize the potent influence of water competition and are not at all afraid of it, but on the contrary, they have met it and must meet it wherever they find it, without complaint and as one of the inevitable conditions under which they have to struggle for existence."

It would seem however, that the railroads have in consequence of this effect, conceived a natural animosity to the canals, and the result has been a war of extermination, and that the object of the railroad managers in acquiring possession of the canals is not to improve or utilize to the greatest extent the capacity of the latter, but to eliminate it from the field as a competitor.

At this time, too, when it is credibly reported that an organization has been formed of the railroads west of Chicago for the purpose of defeating the proposed enlargement of the Illinois and Michigan Canal, so as to render it navigable for vessels of greater draught, it is particularly appropriate to recall the words of Ex-Senator Windom, (now Secretary of the Treasury) then chairman of the Committee on Transportation to the Seaboard. In addressing the Senate, on June 10th, 1878, during the consideration of the bill "making appropriations for the construction, repair and preservation and completion of certain public works on rivers and harbors," he said :

> "The chief instrumentalities by means of which these (competitive) forces will exert their power are the Mississippi river on the one side and the Northern water routes on the other. * * * Both routes constitute indispensable parts of one grand system. * * * Each is needed to regulate the other, and both as regulators of railway charges. Each has some advantages which the other lacks and some impediment which the other has not; but on the whole their trade forces, commercial facilities and economic capacity for cheap transportation will be so evenly balanced as to insure a healthy, active and permanent competition. It will be as impossible for them (the railroads) to combine to put up prices as to effect a combination of interests between Chicago and St. Louis or New York and New Orleans. The interests of the lines themselves are necessarily antagonistic, and as each will be an open, free highway to everybody who chooses to float a vessel upon its waters, combination will be simply impossible and competition the inevitable law of their existence. But the competitive power and influence of the two great contestants (the water and the railroad lines) will not be limited to any one locality, but will extend to nearly every State in the Union, and will hold in check and regulate the charges on every railroad from the interior to the seaboard. The wide sweep of competitive influence exerted by the Erie canal is not generally understood or appreciated. You would doubtless be surprised, Mr. President, if I told you that the 'little ditch' which runs through your State holds in check and regulates nearly every leading railroad east of the Mississippi river, and that it exerts a marked influence on the cost of transportation over all the country extending from the interior of the Gulf States to the St. Lawrence river, and from the great plains of the eastern foothills of the Rocky Mountains to the Atlantic Ocean. And yet such is the fact."

This generalization is then followed by extensive quotations from Mr. Albert Fink, in support of these statements, to the effect that—

> "The Erie Canal and the lakes exercise their influence over the Southern country until it reaches a line where low ocean rates from New York to the Gulf States—Mobile, New Orleans and Galveston—exercises their influence upon the rates to the adjacent interior points—to Augusta, Macon, Selma, Montgomery, Houston, &c.—so that it may be said that the all-rail rates are kept in check by water transportation. There need be no fear that extortionate rates will be charged by railroad companies; on the contrary, the fear is that water competition will be so effective as to prevent railroads from securing paying rates."

The closing sentence reveals the reason for the policy of the railroads and shows how vital it may be for a railroad in competition with a canal to gain control of the latter; but not, we think, for the purpose of exterminating or abandoning it. Rather let us say as an important and useful auxiliary whereby the revenues of the railroad may be augmented without taxing the public to maintain the higher railroad rate.

It is a well remembered fact that after the enlargement of the Schuylkill canal in 1846, the charge per ton on coal from Pottsville to Philadelphia, about one hundred and six miles, was forty cents for toll and fifty for freight, making a total of ninety cents; whereas now, since the canal has been acquired by the Philadelphia and Reading Railroad Company, the charges are the same as those by rail, or one hundred and seventy cents for the same service. Thus nearly one hundred per cent. is paid by the consumers, unnecessarily, and the price of all articles manufactured from this coal is increased accordingly.

At the old rate of nine mills per ton per mile there was a large margin for profit on the canal, and at this same rate, with the exceptional facilities possessed by this down-grade railroad, there should still be a handsome profit. Yet the competition being destroyed, the policy of charging "what the traffic will bear" is too great to be resisted, and industries are stifled.

In an able article on American Industrial Progress, the London Engineering of July 5, 1889, says, after quoting the statistics of our material growth, as evinced in the increase of agricultural products :

> "Under every heading there has been an enormous expansion of business, accompanied in the majority of cases by a considerable fall in values." * * * "In other words 2,660,000,000 bushels in 1887 were worth less than 1,330,000,000 bushels twenty years before."
>
> "This very striking decline of prices has been due no doubt to better systems of cultivation, and to economy in many directions, but it has been chiefly caused by the reductions that have taken place in the cost of transport and the facilities that have been provided throughout the United States for the distribution and consequent equalization of prices of the products of agriculture generally. * * While in 1860 there were only 30,626 miles of railroad, and in 1870, 52,865, in 1888 the mileage had expanded to 157,000; but the increase in traffic has been phenomenal, and is closely allied to the remarkable reduction in the rates of freight that has taken place within recent years. We find for example, that in 1868 the average freight charge on the eighteen principal railroad lines of the United States was 2.453 cents per ton per mile. But in 1878 it was only 1.401, being a reduction of 42 per cent. In 1878 there were many who believed that there was no further room for reduction of freight rates, yet we find that in 1887 the average ton-mile rate on the same roads was only .974 cents, or a further reduction of 30 per cent. In 1887 the great bulk of the freight carried on the railroads of the United States was taken at 60 per cent. less than in 1868. This remarkable movement has been the life's blood of the industrial and commercial development that has occurred in the interval. The freight earnings have kept up and they amounted to over $636,500,000 in 1887 as compared with 294,500,000 in 1871, and the net earnings within the same period have advanced from $141,750,000 to 335,000,000. Obviously if the rates of twenty, or even ten years ago had been kept up to the present time, the relative net earnings would probably have been higher, but the business done would have been infinitely less. The total tonnage transported in 1887 amounted to 552,000,000 tons of freight of all kinds."

A similar development has taken place in the mineral industries of the United States, due to the increased facilities for distribution. The basis of mineral wealth is coal, and it is scattered through twenty-eight states and territories. In 1870, less than 33,000,000 tons were mined in the nineteen states in which it was then known to exist, while in 1887 the output had increased to 111,000,000 tons. But this is only one of the forces taken from the storehouse of a beneficent Creator. Another remarkable development is to be noted in the case of natural gas, which was almost unknown but a decade ago, while in 1887 it represented over $16,000,000. The existence and production of petroleum have also largely increased. Within a few years the consumption of copper has doubled, whilst iron and steel have kept pace with coal and other fuels.

These magnificent results are, to a great extent directly due to the reduction in the tariffs charged by the transportation companies, which, as has been shown, are regulated by the rates fixed by the water ways ; and yet they are not as low as they may be, for it is manifest there is still a large profitable margin on the rates for freight in bulk by canals of enlarged capacity, which might be utilized for the public benefit and the further extension of the market range of our manufactured articles, in the trade of the world.

The importance of ship canals and their utility in shortening the commercial routes of the world is universally conceded, yet there are other canals, purely local in their functions, which carry a larger business than even that at Suez. For example, the Sault Ste Mary Canal, which was recently enlarged to accommodate the rapidly increasing commerce of the Lake Superior region, and which in consequence of its latitude is closed nearly fifty per cent. of the time, has outstripped its oriental competitor in the volume of its tonnage—and it is again too small to handle the rapidly increasing traffic.

In 1870, when the Suez canal was opened, the number of vessels in transit was 486, the net tonnage 436,609, and the average toll per ton $1.99. In 1888, the corresponding figures were 3,440 vessels, 6,640,834 tons, and $1.89 per ton toll. The gross receipts from tolls were $12,607,524.00. The canal is open all the year.

From 1881, when the Sault canal was enlarged, to 1888 inclusive, it was open an average of 193 days of each year, or fifty-three per cent. of the time. The number of vessels increased in the nine years from 1881 to 1889, from 3,304 to 8,832, the net tonnage from 1,802,571 to 6,932,203,and the operating expenses per ton have fallen from 12 mills in 1882, to 5 mills in 1888. In 1889 the net tonnage was 7,516,022, and the number of vessels 9,579.

Per contra we find at the other end of this chain of great lakes, the Erie canal, on which the amount of traffic has remained remarkably constant for fifteen years, fluctuating at about five million tons.

The increase of tonnage is carried by the railways, and it has expanded to the enormous amount of 35,000,000 tons, which, it is safe to assert, would still be in the distant future had it not been for the existence and silent, yet potent, influence of this artificial water way, which has inspired competition and controlled rates. Yet this is the friend which the railways desire to strangle upon the plea that its days of usefulness are over. Such a result would be a calamity to the country. On the contrary, the beneficial influence of this western water way should be extended as rapidly as possible in both directions,—by the National Government completing the "Great Belt" route from the Mississippi to the Atlantic, and along the coast by the inner line, so frequently described, to Florida, as a measure of national, commercial development and defence. It should be the first step in the defensive measures adopted by Congress, for it is of little use to build vessels to run a blockade and take the risks of storms, on the open ocean, when far greater mobility and safety may be secured inside of the coast line.

But there is another strong reason why the enlargement of the link between New York and Philadelphia, via the Delaware and Raritan Canal, upon a revised location, should not be longer delayed. It would still further increase the facilities existing between the two largest and most populous cities of the country, and would affect directly the local interests of at least five millions of people, and indirectly the welfare of sixty millions.

Possibly it is because of the maxim, "what is everybody's business is nobody's business," that this work has not long since been undertaken, and yet it would seem to be in accordance with the history of many similar works in this country which are limited to the confines of a single state, that they are left to the enterprise and resources of said state to be executed.

What shall be thought of the commercial activity and energy of Americans, when so important an undertaking languishes for a century, while Englishmen do not hesitate to undertake a work of greater magnitude with smaller prospects of returns in the construction of the Manchester Ship Canal, thirty-five miles long, at a cost of a million dollars per mile, and between cities having populations of only 575,000 and 350,000 respectively ?

All the railroads intercepted by the English canal, and which opposed its franchises, are now compelled to modify their location and grades so as to surmount an elevation of seventy-five feet in the clear above the water surface of this canal. The total amount of excavation for this work amounts to over 44,000,000 cubic yards, which must be removed prior to January 1, 1892. The contract was let in January, 1888, and already considerably more than half of the excavation is completed. Exclusive of right of way and terminals, this work has been let in one contract for $22,500,000. Yet there has been no lack of railroad and even canal facilities. Then where shall we look for justification for this enormous expense ? It is to be found merely in the desire to avoid the transshipment or break of bulk at Liverpool, and to provide for a continuation of the voyage 35 miles further by water, at canal rates, into the interior. This channel is to be 26 feet deep and 120 feet wide.

There are some remarkable phases connected with the history of this Delaware and Raritan link of the internal water way, which are full of instruction and suggestion. It is only necessary to review the annual balances, to note the great fluctuations in net returns which have taken place, and when these results are connected with the dates of changes of administration, the effect of the policy of the managers becomes at once remarkably prominent.

The chronology of the important changes is given herewith that the relation of cause and effect may be more readily discerned.

The Delaware and Raritan Canal Company and the Camden and Amboy Railroad Company were both chartered in February, 1830 ; the former to construct a canal to connect the Delaware river at Bordentown with the Raritan at New Brunswick, a distance of 44 miles ; the latter, to connect Camden with Amboy by a railroad across the state of New Jersey. These two companies were consolidated by an act passed in February, 1831, and were thereafter conducted by a single management. The main lines of the railroad and of the canal were both completed in the year 1834, and the branches in 1838. In the meantime the Philadelphia and Trenton Railroad Company was chartered, and in 1836 in was merged into the United Companies by the purchase, by them, of a controlling interest in its stock. At the other end of the route to New York, the New Jersey Railroad and Transportation Company was operating an independent link between New Brunswick and Jersey City, in opposition to the steamers from Amboy to New York, and to extinguish this rivalry an agreement was made in January, 1867, between this company and the others already united, whereby it entered the combination on condition of an equal division of profits between these four companies, viz.: the Delaware and Raritan Canal Company, the Camden and Amboy Railroad, the New Jersey Railroad and the Philadelphia and Trenton Railroad Companies—thus forming the United Companies of New Jersey.

In his annual message to the stockholders in 1870, the President of the Pennsylvania Railroad Company called attention to the desirability of securing a through line to New York, by the lease of the lines of these United Companies, and in June of 1871 this lease was consummated, and the entire property was secured for a period of 999 years for an annual rental of ten per centum guaranteed on the aggregate capital and dividends to an equal extent on the Philadelphia and Trenton Railroad.

There is a bit of unwritten history connected with this transaction which is well authenticated, and which serves to explain to some extent the subsequent events relating to this important line of traffic. When it was learned that this lease was contemplated, the President of the Philadelphia and Reading Railroad also entered the field as a competitor for the use of the canal through which that company was then shipping nearly two million tons of coal per annum.

To avoid complications from competitive bids, an alleged agent made an agreement with the Philadelphia and Reading Railroad whereby the use of the canal was assured to that company on satisfactory terms, provided they would withhold their bid. This they did, and, as the story goes, after the lease was effected, it was found that the agent so-called, was acting without authority, and the trade of the Philadelphia and Reading Railroad Company was soon after driven from the canal. Thus was killed the goose that laid the golden egg. This outlet by the canal to New York being thus cut off, the P. & R. R. R. Co. a few years later, or in May, 1879, succeeded in effecting a lease with the North Pennsylvania and the Delaware and Bound Brook Railroads, and thus opened up a new competitive route to New York by rail. The colliers were put on in 1869 to carry coal via the river and ocean to eastern and southern ports. The Central Railroad of New Jersey was also leased May 29, 1883, for 999 years, but this lease was surrendered January 1, 1887.

As the sequel will show, the loss of this heavy coal tonnage was a serious matter for the canal and the United Companies, but when great transportation corporations cross swords, the stockholders as well as the public must bear the brunt of the conflict.

An examination of the balances of the Delaware and Raritan Canal Company, hereto appended, show a remarkable curve of fluctuations. There is a rapid increase of profits up to the year 1866, when the net revenue reached a maximum of $933,642.86 over and above the gross expenses, which were only $360,513.83. In other words the profits were nearly three hundred per cent. of the operating expenses—truly a magnificent showing.

The traffic through the canal, so far as it can be determined from the incomplete tables accessible, was larger this year than any other. From this time the net returns are found to decrease to date—reaching a minimum in 1887, when they were reported as only $80,059.91. But this does not represent the true condition of affairs, for from the time of leasing the United Companies of New Jersey, the Pennsylvania Railroad Company guaranteed ten per cent. on the capital stock of the several companies, and at that time the canal capital was valued at $5,847,400, making a fixed charge of $584,740.00 to be paid annually. It will be seen that after the date of the lease there were but two years when the balance exceeded this amount. Hence, it is said "the canal does not pay" and its traffic is allowed to fall into decay. The same is true, but to a much greater extent, as to the deficit on the railroads, and the annual reports of the Pennsylvania Railroad will show a loss on these United lines reaching, in some years, the large amount of over one million dollars. But this is the price the company elected to pay for the privilege of shipping its traffic at the Jersey City and other termini, instead of at Philadelphia ; and there are possibly compensating advantages which do not appear on the balance sheets of this part of the route.

It is difficult to understand why the more bulky, inferior freights are not transported via the river and canal as formerly, instead of by the more expensive rail routes, even if the charges by canal be kept, by the management, the same as those by rail ; for the cost of the movement being less, the profits would be increased and a large part of the rolling stock of the railroads would thus be released for use on the western branches where there is great dearth of cars. It would, it is believed, be still better if the capacity of the canal were enlarged and its alignment rectified, thereby shortening the distance, about six miles, and thus promoting an additional traffic between Philadelphia, New York and other cities by these additional facilities.

Either this, or else let the canal be sold to the United States and be improved by it as a part of the internal water way to be made free as the rivers. Thus the railroad would eliminate an annual deficit of over half a million dollars and the country be greatly benefitted. It will be presumed that this free water line would be detrimental to the railroad interests, but paradoxical as it may seem, the results are generally the other way, and the existence of a free navigable channel is found to be beneficial to the railroads bordering its banks. The reason is manifest. Population is more dense where there are facilities and an independent outlet, and population is the life of trade.

The canal balances, so far as they could conveniently be ascertained, are shown in the annexed tables :

	Expenses.	Receipts.	Profits.	Inc. or Dec. over previous years.
1852	$132,048.43	$376,585.11	$244,536.68	[1]89.450.63
1859	157,068.66	492,198.00	335,129.34	
1860[2]	117,968.86	546,650.59	428,681.73	
1861[1]	157,509.53[1]	469,895.73	312,386.20	
1862[4]	172,091.80	517,655.63	345,563.83	
1863[5]	190,883.89	728,365.73	537,481.84	
1864[6]	280,390.29	1,065,024.26	784,633.97	
1865[7]	317,577.75	1,128,007.30	810,429.65	
1866	360,513.83	1,294,156.69	933,642.86	
1 yr. missing	....	....	....	
1868	325,560.56	912,107.77	596,547.21	
1869	311,681.86	1,043,865.64	731,683.78	
1870	602,173.73	1,222,995.06	620,821.33	
1871	701,029.96	1,429,594.11	728,564.15	
1872	1,016,037.49	1,524,605.24	508,567.75	
1873	883,321.46	1,590,100.12	706,778.66	
1874	768,416.64	1,320,519.23	552.102.59	
1875	541,035.76	1,067,660.58	526,624.82	
1876	523,306.02	882,551.78	359,245.76	
1877	477,606.78	896,569.65	418,962.87	
1878	389,720.25	702,083.45	312,363.20	
1879	326,924.85	695,959.10	369,034.25	
1880	331,343.53	419,430.57	88,087.04	
1881	232,314.17	541,076.73	308,762.56	
1882	294,780.13	553,417.70	258,637.57	
1883	291,574.56	548,055.21	256,480.65	
1884	381,403.87	547,710.66	161,306.79	
1885	342,373.94	529,079.06	186,705.12	
1886	390,705.41	535,525.99	142,820.58	
1887	414,158.81	494,218.72	80,059.91	
1888	430,680.31	525,748.92	95,068.61	
1889	....	....	....	

1883—To pay on account of dividends on canal,	$584,740.00
" " transient dues and taxes,	74.530.24

Main line, 44 ; feeder, 22 ; total, 66 miles.

[1] During the civil war, 1861-1865.

[1] In the report for 1861, the Directors say :—"The State Directors having observed a movement in the Congress of the United States in reference to the construction of a Military and Postal Railroad between the city of New York and Washington, deem it their duty to call the attention of the Governor to the subject, that he might adopt such measures as in his judgment would best protect the interests of the state; and they now express the sentiment that it would not be expected that the state of New Jersey would quietly submit to such an encroachment upon her sovereignty and the destruction of an important pecuniary interest, unless the safety and best interests of the country required it. They are fully persuaded that no such necessity does exist."

[2] For 245,825 tons of "superior" freight the charge was eight cents per ton. For 1,394,172 tons of "inferior" freight the charge was two cents per ton..

[3] "For maintaining and operating the canal, including repairs and transit duty paid to the state."

[4] The report for 1862 renews the protest against the Military and Postal road between Washington and New York by Congress.

[5] [6] [7] A still more emphatic protest.

Incomplete Tabular Statement of traffic through the Delaware and Raritan Canal,

	1852.	1859.	1860.	1861.	1862.	1863.	1864.	1865.	1866.	1867.	1868.	1869.
Coal, tons......	998,302	1,155,261	1,283,264	1,022,902	1,007,718	1,262,032	1,329,082	1,552,108	2,282,203		1,923,532	1,888,003
Timber, c. ft....	2.734,031	1,606,558	2,314,749	1,472,475	2,282,789	3,174,035	3,050,470	2,878,206	2,864,915		2,468,568	3,328,731
Lumber, b. m...	6,655,916	11,886,488	11,878,913	6,502,020	14,232,470	13,839,792	14,358,992	14,143,297	16,362,237		18,893,913	15,811,117
Grain, bushels..	840,559	657,736	742,001	825,578	902,426	2,644,745	2,072,821	2,476,683	3,379,088		1,974,227	1,434,250
Flour, barrels...	119,166	164,219	211,203	101,202	195,022	248,352	266,647	208.838	185,694		21,369	281,646
Iron, tons......	31,391	31,825	40,032	28,766	39,614	48,661	48,648	41,143	55,291		63,142	54,893
Mdse., tons.....	135,299	209,481	227,394	239,642	322,727	357,169	287,358	295,388	354,341		402,931	468,605

The gross tonnage for a few other years not itemized, is reported to be, for 1874, 2,308,670 ; for 1875, 1,958,004 ; for 1876, 1,897,708 ; while for 1868 it was 2,519,285 ; and for 1869, 2,547,212 ; or over half a million tons more than after the lease.

In 1874, the coal shipments were but 1,548,303 tons.

The main line was 44 miles in length, with a feeder extending from Trenton to Bull's Island, 22 miles, giving a total of 66 miles. It was 80 feet wide at the surface and seven (7) feet deep.

The Report of 1882 says :

> "In consequence of the large increase of transportation upon the canal, the company have decided to enlarge its dimensions so as to leave in all places eight feet clear depth of water, and to lengthen the locks from one hundred and ten to two hundred and twenty feet, so as to take in two of the present boats, or one of two hundred and twenty feet in length and capacity of five hundred tons.
>
> The estimated cost of these improvements, and to carry out the plan of enlargement, is $700,000."

In the Report for 1866 are to be found these items:

The cost of the Camden and Amboy Railroad and equipments is	$10,099,000.97
The cost of the Delaware and Raritan Canal and appurtenances is	$4,381,251.28

The receipts of the Camden and Amboy Railroad and Transportation Company for the twelve months ending December 31, 1866	$4,312,895.00
Expenses	3,801,732.45
Current net	$511,162.55

The receipts of the Delaware and Raritan Canal Company for twelve months ending December 31, 1866	$1,294,156.69
Expenses	360,513.83
Current net	$933,642.86

This statement shows very conclusively that upon a capital of over four million dollars invested in the canal, the net returns were nearly 23 per cent.; while upon the capital of over ten millions invested in the railway, the net return was only a little more than 5 per cent. For an equivalent return, the railroad capital should have produced a profit of $2,152,100. In other words, although the rates by canal were less than those by rail, the cost of maintenance and operation were so much smaller, that its returns were nearly five-fold greater than those of the railroad. It was further stated that "while the business of the railroad, both in passengers and freight was not equal to that of the previous year, that of the canal was increased to almost its entire (present) capacity. A new outlet lock is being constructed at New Brunswick, which will greatly facilitate the dispatch of their tonnage."

Interesting as this history may be, it is not an isolated case. It is a common experience to note in our technical press such items as this. "The Old Pennsylvania Canal, that has been in service for sixty years, is now practically abandoned, and its bed is to be used by the Pennsylvania Railroad. This road owns the canal, and is at work destroying the old aqueducts, bridges, etc., and is straightening out its line in many places by using the canal bed. Portions of the canal were in use up to the present year."[1]

The history of another of the great arteries of Pennsylvania, the Schuylkill Navigation Company's Canal, is nearly the same. Efforts are now making to divert it from its original purpose of a navigable channel, to an open aqueduct for the supply of potable water to the city of Philadelphia, but there is a somewhat pathetic story connected with its early life which will serve to illustrate the great service this canal has rendered in making Philadelphia what she is to-day.

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[1] *Engineering News*, Jan. 4, 1890.

Although coal was quarried at Summit Hill in 1792, it had no market value, as there were no means of transporting it and it was not known how to make it burn readily.

The Schuylkill Canal was opened from Philadelphia to Mount Carbon in 1825, but shortly before that date a prominent citizen had a load of coal conveyed by wagon from the quarry at a cost of thirteen dollars and a half. He had subscribed largely to the stock of the proposed navigation company, and his friends thought him visionary. Upon the arrival of the coal he had a grate constructed in his parlor, upon which a "stone coal" fire was soon kindled. His house was besieged by the interested and curious citizens of Philadelphia, who wished to see this marvelous phenomenon. Amongst the visitors was an acquaintance who had protested vigorously against his friend's extravagant investment in the canal securities, but who, on seeing the coal fire burning so successfully, and throwing out such great heat, gave vent to his pent up feelings in tears. When asked why he displayed so much emotion, he replied, that for years he had been deeply concerned about the welfare of his children and grand-children, in wondering how they could obtain sufficient hard wood for fuel during the winters, when it was then selling at $18 a cord for hickory, and $13 for oak. His fears were allayed by the phenomenon before him, and his gratitude to a beneficent Creator thus expressed itself.[1]

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[1] This anecdote was related to the writer recently by Hon. Fred'k Fraley, who was an eye witness of the events described.

Instead of wood at the above prices, or coal hauled by wagon at $13 for the partial load, the canal subsequently delivered unlimited quantities of this fuel at the rate of 90 cents per ton for tolls and freight. The value of this stimulus to the manufacturing industries of Philadelphia and the adjacent territory, can hardly be over-estimated, and had it not been for the impetus given to the commerce of New York by the opening of the Erie Canal in 1825, Philadelphia might have retained her envied position as the first city in population in the United States.

This early canal through New York State had a prism of only four feet draught, carrying boats of seventy-six tons capacity, and was operated at a cost of 4.14 mills per ton per mile, while on the enlarged canal having a depth of seven feet and boats of 210 tons capacity, the reduced cost was 2.16 mills.[1] Again, upon the projected re-enlarged 8 feet canal, with boats of 600 tons, the cost was estimated by the State Engineer in 1863 at only 1.04 mills per ton per mile. Before this canal was built the cost of transportation from Buffalo to New York was $100 per ton, and the length of time required for the trip was *twenty* days.

On the 14th of March, 1835, Messrs. J. B. Jervis, H. Hutchinson and F. W. Mills reported to the canal Commissioners that: "Taking the facts we have obtained as a basis, we find the relative cost of conveyance (by rail and canal) is as 4.375 to 1,000, a little over four and one-third in favor of canals, this is exclusive of tolls or profits. * * * We are led to the conclusion that in regard to the cost of construction and maintenance, and also in reference to the expense of conveyance at moderate velocities, canals are clearly the most advantageous means of communication, &c."

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[1] The general rule already stated would give 2.36 mills.

The velocity of movement does affect greatly the utility of the canal. The resistance increasing with the square of the velocity, for high speeds much greater power is required in these contracted channels, so that the practical limit for steamers on ship canals like the Suez, is found to be from five to six miles per hour. Velocity on a canal is equivalent to grade on a railroad, since it creates a hill or grade against the boat.

From the character of this evidence it will appear that even the early canals of small draught were cheaper modes of transportation than the railroads which were then charging about 2½ to 3 cents per ton per mile, and when Genl. H. Haupt, chief engineer of the Pennsylvania railroad, about 1854, proposed to reduce the rate to about one-half of this and increase the volume of the tonnage proportionately, it met with violent opposition from the board of directors, and was believed to be a ruinous policy. Now, however, the road is carrying a large portion of its enormous tonnage for less than one-half a cent, and making money.

But the time has evidently arrived when it will pay to enlarge some of the existing trunk line water ways to the dimensions of ship channels, especially where they form links in a water communication between populous communities. The enlargement of the Delaware and Raritan and the Delaware and Chesapeake are works which should no longer be delayed.